PART 2

Air Distribution

Carrier

CONTENTS PART 2 AIR DISTRIBUTION

SYSTEM DESIGN MANUAL

SUMMARY OF PART TWO

This part of the System Design Manual presents data and examples to the engineer in practical design and layout of air handling equipment, ductwork and air destribution components.

The text of this manual is offered as a general guide for the use of industry and of consulting engineers in designing systems. Judgment is required for application to specific installation, and Carrier is not responsible for any uses made of this text.

CHAPTER 1. AIR HANDLING APPARATUS

This chapter describes the location and layout of air handling apparatus from the outdoor air intake thru the fan discharge on a standard air conditioning system. Construction details are also included for convenience.

Air handling apparatus can be of three types: (1) built-up apparatus where the casing for the conditioning equipment is fabricated and installed at or near the job site; (2) fan coil equipment that is manufactured and shipped to the job site, either completely or partially assembled; and (3) self-contained equipment which is shipped to the job site completely assembled.

This chapter is primarily concerned with built-up apparatus; fan coil and self-contained equipment are discussed in Part 6. In addition to the built-up apparatus, items such as outdoor air louvers, dampers, and fan discharge connections are also discussed in the chapter. These items are applied to all types of apparatus.

Equipment location and equipment layout must be carefully studied when designing are handling apparatus. Thus two items are discussed in detail in the following pages.

LOCATION

The location of the air handling apparatus directly influence the economic and sound level aspects of any system.

ECONOMIC CONSIDERATION

The air handling apparatus should be centrally located to obtain a minimum-first-cost system. In a few instances, however, it may be necessary to locate the apparatus, refrigeration machine, and cooling tower in one area, to achieve optimum system cost. When the three components are grouped in one location, the cost of extra ductwork is offset by the reduced piping cost. In addition, when the complete system becomes large enough to require more than one refrigeration machine, grouping the mechanical equipment on more than one floor becomes practical. This design is often used in large buildings. The upper floor equipment handles approximately the top 20 to 30 floors, and the lower floor equipment is used for the lower 20 to 30 floors.

Occasionally a system is designed requiring a grouping of several units in one location, and the use of single unit in a remote location. This condition should be carefully studied to obtain the optimum coil selection-versus-piping cost for the remotely located unit. Often, the cost of extra coil surface is more than offset by the lower pipe cost for the smaller water quantity resulting when the extra surface coil is used.

SOUND LEVEL CONSIDERATIONS

It is extremely important to locate the air handling apparatus in areas where reasonable sound levels can be tolerated. Locating apparatus in the conditioned space or adjacent to areas such as conference rooms, sleeping quarters and broadcasting studios is not recommended. The following items point up the conditions that are usually created by improper location; these conditions can be eliminated by careful planning when making the initial placement of equipment:

1. The cost of correcting a sound or vibration problem after installation is much more than the original cost of preventing it.
2. It may be impossible to completely correct the sound level, once the job is installed.
3. The owner may not be convinced even after the trouble has been corrected.

The following practices are recommended to help avoid sound problems for equipment rooms located on upper floors.

1. In new construction, locate the steel floor framing to match equipment supports designed for weights, reactions and speeds to be used. This transfers the loads to the building columns.
2. In existing buildings, use of existing floor slabs should be avoided. Floor deflection can, at times, magnify vibration in the building structure. Supplemental steel framing is often necessary to avoid this problem.
3. Equipment rooms adjacent to occupied spaces should be acoustically treated.
4. In apartments, hotels, hospitals and similar buildings, non-bearing partition walls should be separated at the floor and ceilings adjoining occupied spaces by resilient materials to avoid transmission of noise vibration.
5. Bearing walls adjacent to equipment rooms should be acoustically treated on the occupied side of the wall.

LAYOUT

Package equipment is usually factory shipped with all of the major equipment elements in one unit. With this arrangement, the installation can be completed by merely connecting the ductwork and assembling and installing the accessories.

In a central station system, however, a complete, workable and pleasing layout must be made of all major components. This involves considerations usually not present in the unitary equipment installation.

The shape and cross-sectional area of the air handling equipment are the factors that determine the dimensions of the layout. The dehumidifier assembly or the air cleaning equipment usually dictates the overall shape and dimensions. A superior air handling system design has a regular shape. A typical apparatus is shown in *Fig 1*. The shape shown allows for a saving in sheet metal fabrication time and, therefore, is considered to be better industrial appearance. From a functional standpoint, an irregular shaped casing tends to cause air stratification and irregular flow patterns.

The most important rule in locating the equipment for the air handling apparatus is to arrange the equipment along a center line for the best air flow conditions. This arrangement keeps plenum pressure losses to a minimum, and is illustrated in *Fig 1*.

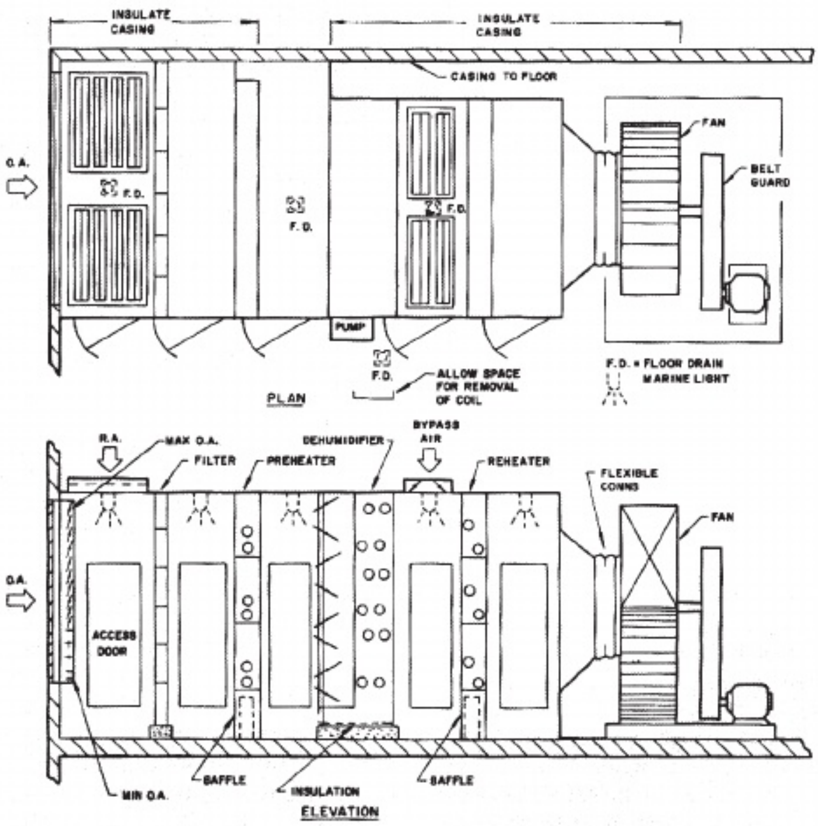


Fig. 1 – Typical Central Station Equipment

It is best to locate the outdoor air louver in such a manner that cross contamination from exhaust fan to louver does not occur, specifically toilet and kitchen exhaust. In addition, the outdoor air intake is located to minimize pulling air over a long stretch of roof since this increases the outdoor air load during summer operation.

Chart 1 is used to estimate the air pressure loss at various face velocities when the outdoor louvers are constructed, as shown in *Fig 2.*

There are occasions when outdoor air must be drawn into the apparatus thru the roof. One convenient method of accomplishing this is shown in *Fig 3.* The gooseneck arrangement shown in this figure is also useful for exhaust systems.

LOUVER DAMPERS

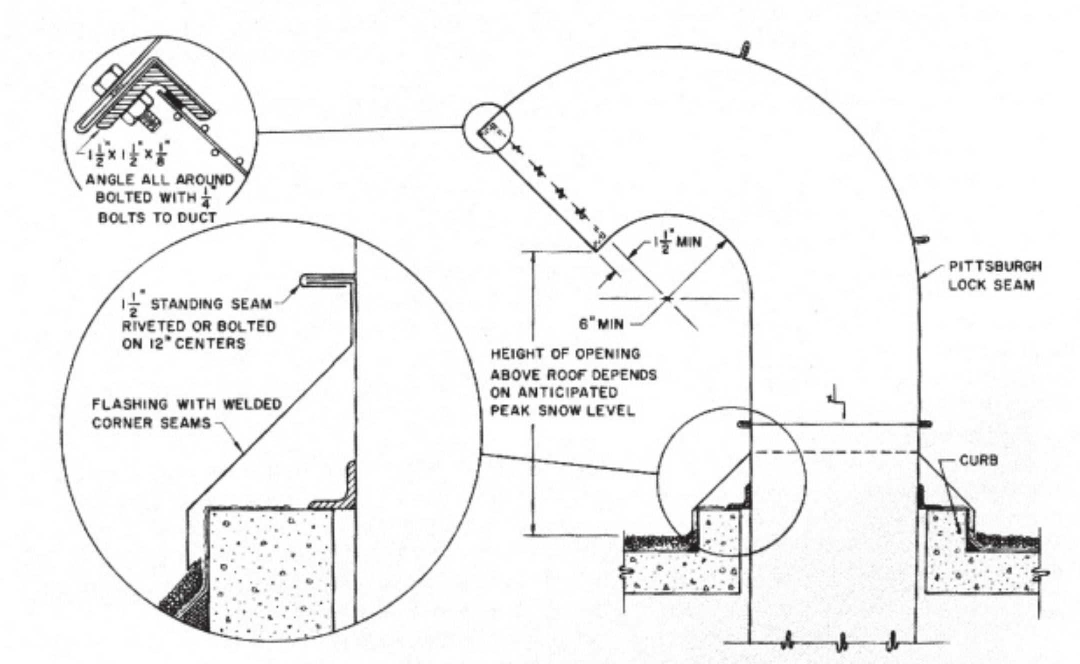
The louver damper is used for three important functions in the air handling apparatus: (1) to control and mix outdoor and return air; (2) to bypass heat transfer equipment; and (3) to control air quantities handled by the fan.

Fig. 4 shows two damper blade arrangements. The single action damper is used in locations where the damper is either fully open or fully closed. A double-acting damper is used where control of air flow is required. This arrangement is superior since the air flow is throttled more or less in proportion to the blade position, whereas the single action type damper tends to divert the air and does little or no throttling until the blades are nearly closed.

Outdoor and return air dampers are located so that good mixing of the two air streams occurs. On installations that operate 24 hours a day and are located in a mild climate, the outdoor damper is occasionally omitted.

With the fan operating and the damper fully closed, leakage cannot be completely eliminated. *Chart 2* is used to approximate the leakage that occurs, based on an anticipated pressure difference across the closed damper.

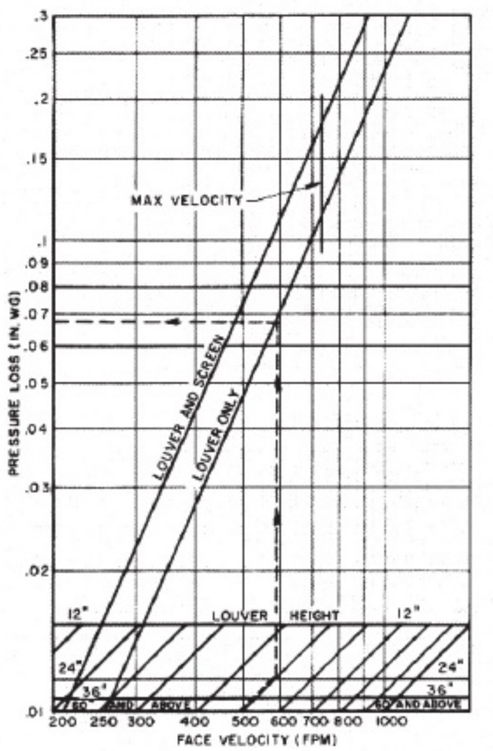
Table 1 gives recommendations for various louver dampers according to function, application, velocities and type of action required.



NOTE: Supplemental wind bracing may be required on larger intakes.

Fig. 3 – Gooseneck Outside Air Intake

CHART 1 – LOUVER PRESSURE DROP



EXAMPLE

Given: 24" high stationary louver with 500 fpm face velocity. No screen.
Find: Pressure loss
Solution: Pressure loss = .067 in. wg

CHART 2 – LOUVER DAMPER LEAKAGE

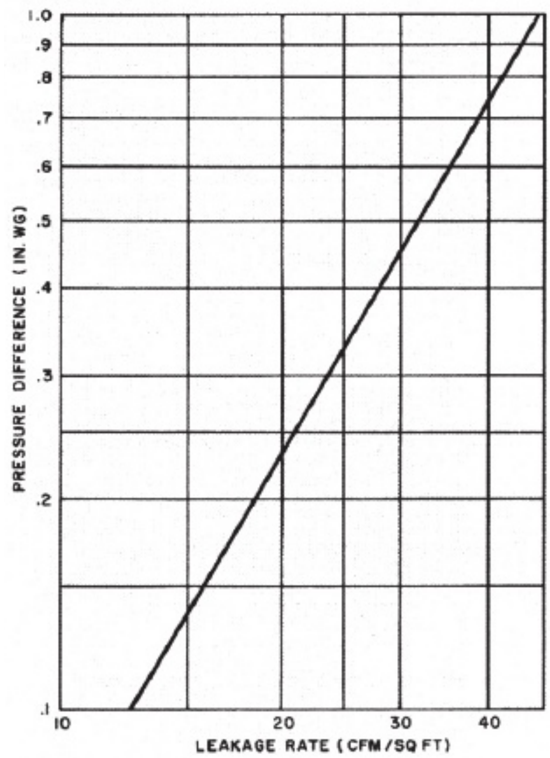
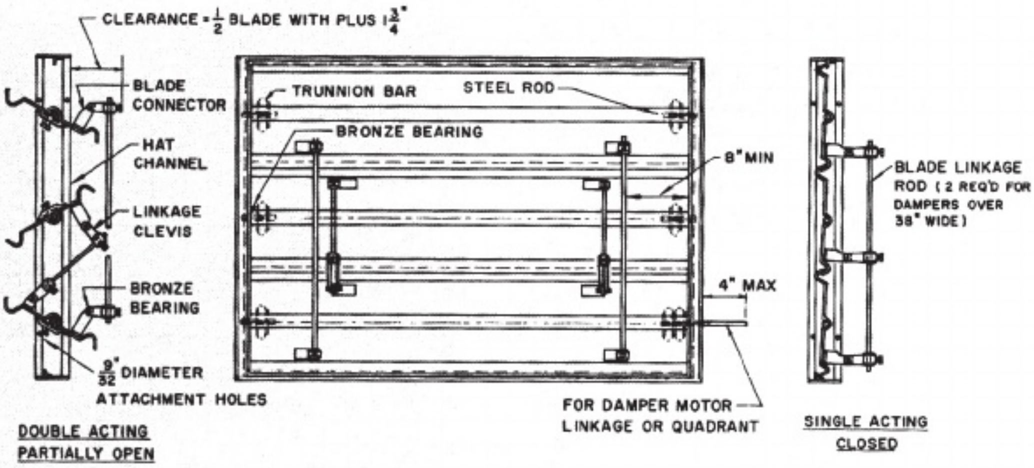
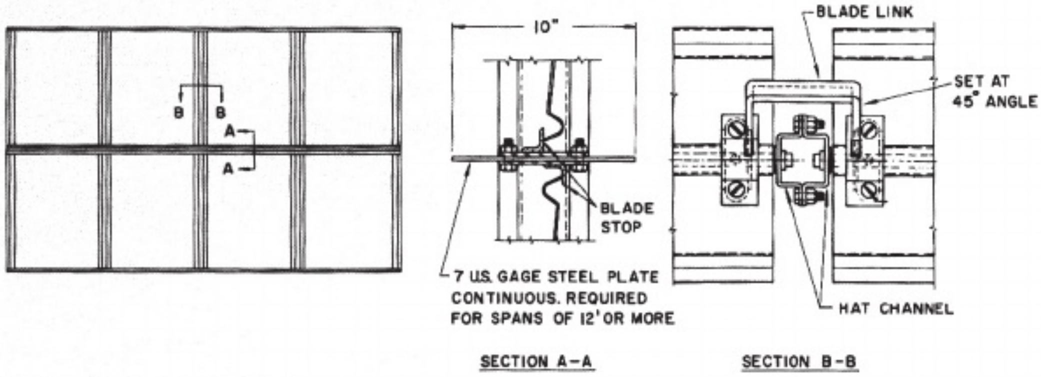


TABLE 1 – LOUVER DAMPERS

FUNCTION OR LOCATION	APPLICATION	VELOCITY* (fpm)	REMARKS
Minimum Outdoor Air	Ventilation	500-800	The higher limit may be used with short outdoor air duct connection and long return air duct. May be single acting damper.
Maximum Outdoor Air	Permissible system resistance and balance	500-800	Should be double acting when used for throttling.
All Outdoor Air	Permissible system resistance and balance	500-800	Single acting damper may be used.
Return Air	Permissible system resistance and balance	800-1200	May be higher velocity with short return duct and long outdoor air duct. Should be double acting damper.
Dehumidifier Face	Control space conditions	400-800	Should equal cross-sectional area of dehumidifier. Should be a double acting damper.
Dehumidifier Bypass	System balance	1500-2500	Should balance resistance of dehumidifier plus humidifier face damper. Should be double acting.
Heater Bypass	Balance	1000-1500	Should balance resistance at heater. Should be double acting.
Fan Suction or Discharge or Located in Duct	Available duct area	same as duct	Use double acting damper.



SINGLE LOUVER DAMPER



MULTIPLE LOUVER DAMPER ASSEMBLY
(FOR ASSEMBLY EXCEEDING MAXIMUM DIMENSIONS)

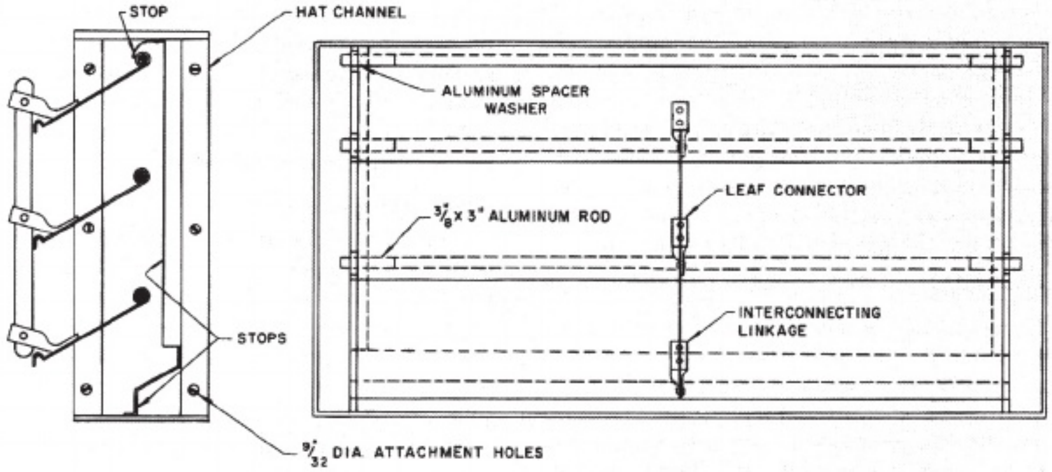
MATERIAL SPECIFICATIONS

Maximum Over-all Height	91½"
Maximum Over-all Width	50"
Maximum Blade Width	12"
Frame — Top and Bottom	3" x ⅛" flat bar
— Sides	3" x ⅞" x ⅛" hat channel
Blades	16 U.S. gage steel
Bearing	Oil-retaining porous bronze
Blade Linkage Rod	5/16" dia. CRS
Trunnion	Die-formed steel
Blade Link (Multi-section)	Stainless steel bar

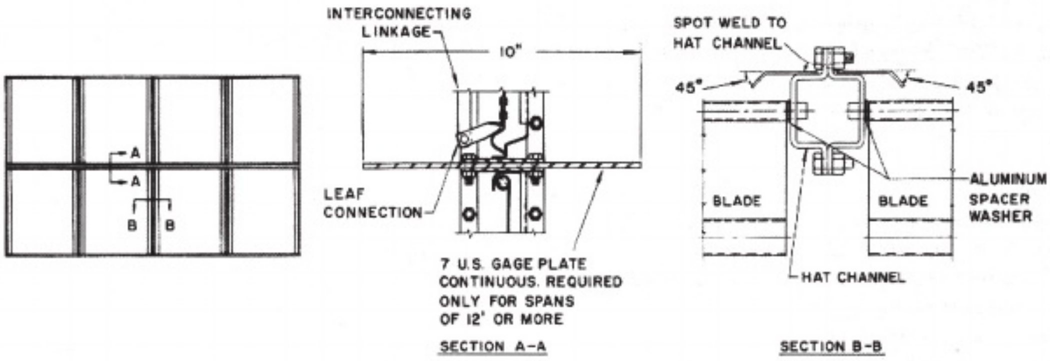
BLADES

DAMPER HEIGHT (in.)	NUMBER OF BLADES
To and incl. 12-11/16	1
12¾ thru 21½	2
21 9/16 thru 31½	3
31 9/16 thru 41½	4
41 9/16 thru 51½	5
51 9/16 thru 61½	6
61 9/16 thru 71½	7
71 9/16 thru 81½	8
81 9/16 thru 91½	9

Fig. 4 – Louver Damper Arrangements



SINGLE RELIEF DAMPER



MULTIPLE RELIEF DAMPER ASSEMBLY
(FOR ASSEMBLY EXCEEDING MAXIMUM DIMENSION)

MATERIAL SPECIFICATIONS

Maximum Over-all Height	91½"
Maximum Over-all Width	40"
Maximum Blade Width	3½"
Frame — Top and Bottom	3" wide, 11 gage black iron
— Sides	3" x 7/8" x 1/8" hat channel
Blades	22 B & S gage aluminum
Blade Linkage Rod	½" wide, 0.050" aluminum
Spacer Washer	3/8" ID x ½" OD aluminum

PRESSURE DROP

FACE VELOCITY (fpm)	PRESSURE DROP (in. wg)
400	.067
500	.084
600	.120
700	.160
800	.200
900	.256

Fig. 5 – Relief Damper

RELIEF DAMPERS

Figure 5 shows a typical relief damper. This accessory is used as a check damper on exhaust systems, and to relieve excess pressure from the building.

AIR CLEANING EQUIPMENT

A variety of air filtering devices is available, each with its own application. The pressure drop across these devices must be included when totaling the static pressure against which the fan must operate. Filters are described in detail in *Part 6.*

HEATING COILS

Heating coils can be used with steam or hot water. They are used for preheating, and for tempering or reheating. The air velocity thru the coil is determined by the air quantity and the coil size. The size may also be determined by a space limitation or by the recommended limiting velocity of 500 to 800 fpm. The number of rows and fin spacing is determined by the required temperature rise. Manufacturer's data lists pressure drop and capacity for easy selection

Steam coils must be installed so that a minimum of 18 in. is maintained between the condensate outlet and the floor to allow for traps and condensate piping.

Preheat Coils

Non-freeze coils are recommended for preheat service, particularly if air below the freezing temperature is encountered. To reduce the coil first cost, the preheater is often sized and located in only the minimum outdoor air portion of the air handling apparatus. If a coil cannot be selected at the required load and desired steam pressure, it is better to make a selection that is slightly undersize than one that is oversize. An undersized coil aids in preventing coil freeze-up.

The use of two coils for preheating also minimizes the possibility of freeze-up. The first coil is deliberately selected to operate with full steam pressure at all times during winter operation. In this instance, the air is heated from outdoor design to above the freezing temperature. The second coil is selected to heat the air from the freezing temperature to the desired leaving temperature. The temperature of the air leaving the second coil is automatically controlled. Refer to *Part 3, "Freeze-up Protection."*

In addition to the normal steam trap required to drain the coil return header, a steam supply trap immediately ahead of the coil is recommended. These traps must be located outside the apparatus casing.

Most coils are manufactured with a built-in tube pitch to the return header. If the coil is not constructed in this manner, it must be pitched toward the return header when it is installed.

To minimize coil cleaning problems, filters should be installed ahead of the preheaters.

Reheat or Tempering Coils

Coils selected for reheat service are usually oversized. In addition to the required load, a liberal safety factor of from 15% to 25% is recommended. This allows for extra load pickup during early morning operation, and also for duct heat loss which can be particularly significant on long duct runs.

These coils are similar to preheat coils in that the tubes must be pitched toward the return header.

COOLING COILS

Cooling coils are used with chilled water, well water or direct expansion for the purpose of precooling, cooling and dehumidifying or for after cooling. The resulting velocity thru the cooling coil is dictated by the air quantity, coil size, available space, and the coil load. Manufacturer's data gives recommended maximum air velocities above which water carry-over begins to occur.

SPRAYS AND ELIMINATORS

Spray assemblies are used for humidifying dehumidifying or washing the air. One item often overlooked when designing this equipment is the bleeder line located on the discharge side of the pump. In addition to draining the spray heads on shutdown, this line controls the water concentrates in the spray pan. See *Part 5, Water Conditioning.* Eliminators are used after spray chambers to prevent entrained water from entering the duct system.

AIR BYPASS

An air bypass is used for two purposes: (1) to in crease room air circulation and (2) to control leaving air temperature.

The fixed bypass is used when increased air circulation is required in a given space. It permits return air from the room to flow thru the fan without first passing thru a heat exchange device. This arrangement prevents stagnation in the space and maintains a reasonable room circulation factor.

The total airway resistance for this type system is the sum of the total resistance thru the ductwork and air handling apparatus. Therefore, the resistance thru the bypass is normally designed to balance the resistance of the components bypassed. This can be accomplished by using a balancing damper and by varying the size of the by pass opening.

The following formula is suggested for use in sizing the bypass opening :

$$A = \frac{cfm}{581\sqrt{\frac{h}{.0707}}}$$

where : A = damper opening (sq ft)
cfm = maximum required air quantity thru bypass
h = design pressure drop (in. wg) thru bypassed equipment

Temperature control with bypassed air is accomplished with either a face and bypass damper or a controlled bypass damper alone. However, the face and bypass damper arrangement is recommended, since the bypass area becomes very large, and it is difficult to accommodate the required air flow thru the bypass at small partial loads. Even where a controlled face and bypass damper is used, leakage approaching 5% of design air quantity passes thru the face damper when the face damper is closed. This 5% air quantity normally is included when the fan is selected.

See *Part 6* for systems having a variable air flow to determine fan selection and brake horsepower requirements.

FANS

Properly designed approaches and discharges from fans are required for rated fan performance in addition to minimizing noise generation. *Figures 6 and 7* indicate several possible layouts for varying degrees of fan performance. In addition, these figures indicate recommended location of double width fans in plenums. When these minimums have not been met, it becomes increasing difficult to guarantee the fan performance or to accurately determine air quantities.

Fans in basement locations require vibration isolation based on the blade frequency. Usually cork or rubber isolators are satisfactory for this service. On upper floor locations, however, spring mounted concrete bases designed to absorb the lowest natural frequency are recommended.

The importance of controlling sound and vibration cannot be overstressed, particularly on upper floors. The number of fans involved in one location and the quality of sound and vibration control needed.

Small direct connected fans, due to higher operating speed, are generally satisfactorily isolated by rubber or cork.

In addition, all types of fans must have flexible connections to the discharge ductwork and, where required, must have flexible connections to the intake ductwork. Details of a recommended flexible connection are shown in *Fig.8*.

Unitary equipment should be located near columns or over main beams to limit the floor deflection. Rubber or cord properly loaded usually gives the required deflection for efficient operation.

FAN MOTOR AND DRIVE

A proper motor and drive selection aids in long life and minimum service requirements. Direct drive fans are normally used on applications where exact air quantities are not required, because ample energy (steam or hot water, etc.) is available at more than enough temperature difference to compensate for any lack of air quantity that exists. This applies, for example, to a unit heater application. Direct drive fans and also used on applications where system resistance can be accurately determined. However, most air conditioning applications use belt drives.

V-belts must be applied in matched sets and used on balanced sheaves to minimize vibration problems and to assure long life. They are particularly useful on applications where adjustments may be required to obtain more exact air quantities. These adjustments can be accomplished by varying the pitch diameter on adjustable sheaves, of by changing one or both sheaves on a fixed sheave drive.

Belt guards are required for safety on all V-belt drives, and coupling guards are required for direct drive equipment. *Figure 9* illustrates a two-piece belt guard.

The fan motor must be selected for the maximum anticipated brake horsepower requirements of the fan. The motor must be large enough to operate within its rated horse power capacity. Since the fan motor runs continuously, the normal 15% over load allowed by NEMA should be reserved for drive losses and reductions in line voltages. Normal torque motors are used for fan duty.

APPARATUS CASING

The apparatus casing on central station equipment must be designed to avoid restrictions in air flow. In addition, it must have adequate strength to prevent collapse or bowing under maximum operating conditions.

Each sheet of material should be fabricated as a panel and joined together, as illustrated in *Fig 10*, by standing seams bolted or riveted on 12 in. centers.

CHAPTER 2. AIRDUCT DESIGN

The function of a duct system is to transmit air from the air handling apparatus to the space to be conditioned.

To fulfill this function in a practical manner, the system must be designed within the prescribed limits of available space, friction loss, velocity, sound, level, heat and leakage losses and gains.

This chapter discusses these practical design criteria and also considers economic balance between first cost and operating cost. In addition, it offers recommended construction for various types of duct systems.

GENERAL SYSTEM DESIGN

CLASSIFICATION

Supply and return duct systems are classified with respect to the velocity and pressure of the air within the duct.

Velocity

There are two types of air transmission systems used for air conditioning applications. They are called conventional or low velocity and high velocity systems. The dividing line between these systems is rather nebulous but, for the purpose of this chapter, the following initial supply air velocities are offered as a guide:

1. Commercial comfort air conditioning
   a. Low velocity – up to 2500 fpm. Normally between 1200 and 2200 fpm.
   b. High velocity – above 2500 fpm.
2. Factory comfort air conditioning
   a. Low velocity - up to 2500 fpm. Normally between 2200 and 2500 fpm.
   b. High velocity – 2500 to 5000 fpm.

Normally, return air systems for both low and high velocity supply air systems are designed as low velocity systems. The velocity range for commercial and factory comfort application is as follows:

1. Commercial comfort air conditioning – low velocity up to 2000 fpm. Normally between 1500 and 1800 fpm.
2. Factory comfort air conditioning – low velocity up to 2500 fpm. Normally between 1800 and 2200 fpm.

Pressure

Air distribution systems are divided into three pressure categories; low, medium and high. These divisions have the same pressure ranges as Class I, II and III fans as indicated:

1. Low pressure – up to $3^3/_4$ in. wg – Class I fan
2. Medium pressure –$3^3/_4$ to $6^3/_4$ in . wg – Class II fan
3. High pressure – $6^3/_4$ to $12^1/_4$ in. wg – Class III fan

These pressure ranges are total pressure, including the losses thru the air handling apparatus, ductwork and the air terminal in the space.

AVAILABLE SPACE AND ARCHITECTURAL APPEARANCE

The space allotted for the supply and return air conditioning ducts, and the appearance of these ducts often dictates system layout and, in some instances, the type of system layout and, in some instances, the type of system. In hotels and office buildings where space is at a premium, a high velocity system with induction units using small round ducts is often the most practical.

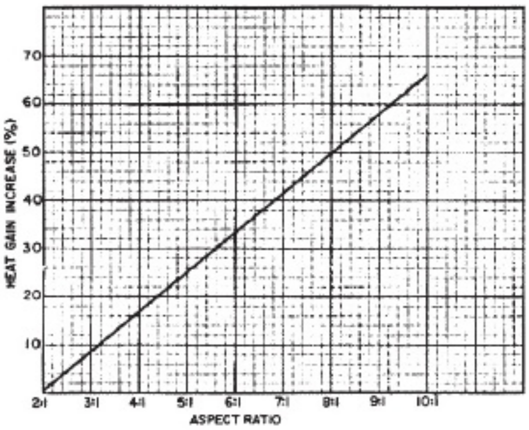
Some applications require the ductwork to be exposed and attached to the ceiling, such as in an existing department store or existing office building. For this type of application, streamline rectangular ductwork is ideal. Streamline ductwork is constructed to give the appearance of a beam on the ceiling. It has a smooth exterior surface with the duct joints fabricated inside the duct. This ductwork is laid out with a minimum number of reductions in size to maintain the beam appearance.

Duct appearance and space allocation in factory air conditioning is usually of secondary importance. A conventional system using rectangular duct work is probably the most economical design for this application.

ECONOMIC FACTORS INFLUENCING DUCT LAYOUT

The balance between first cost and operating cost must be considered in conjunction with the available space for the duct work to determine the best air distribution system. Each application is different and must be analyzed separately; only general rules or principles can be given to guide the engineer in selecting the proper system.

CHART 3 – DUCT HEAT GAIN VS ASPECT RATIO



The following items directly influence the first and operating cost:

1. Heat gain or loss from the duct
2. Aspect ratio of the duct
3. Duct friction rate
4. Type of fittings

Heat Gain or Loss

The heat gains of losses in t6he supply and return duct system can be considerable. This occurs not only if the duct passes thru an unconditioned space but also on long duct in the unconditioned space when estimating the air conditioning load. The method of making this allowance is presented in Part I, Load Estimating. This allowance for duct heat gain increases the cooling capacity of the air. This increase then requires a larger air quantity or lower supply air quantity or lower supply air temperature or both.

To compensate for the cooling or heating effect of the duct surface, a redistribution of the air to the supply outlets is sometimes required in the initial design of the duct system.

The following general guides are offered to help the engineer understand the various factors influencing duct design:

1. Larger duct aspect ratios have more heat gain than ducts with small aspect ratios, with each carrying the same air quantity. Chart 3 illustrates this relationship.
2. Ducts carrying small air quantities at a low velocity have the greatest heat hain.
3. The addition of insulation to the duct decreases duct heat hain; for example, insulating the duct with a material that has a U value of .12 decreases heat gain 90%

It is, therefore, good practice to design the duct system for low aspect ratios and higher velocities to minimize heat gain to the duct. If the duct is to run thru an unconditioned area, it should be insulated.

Aspect Ratio

The aspect ratio is the ratio of the long side to the short side of a duct. This ratio is an important factor to be considered in the initial design. Increasing the aspect ratio increases both the installed cost and the operating cost of the system.

The installed or first cost of the duct work depends on the amount of material used and the difficulty experienced in fabricating the ducts. Table 6 reflects these factors. This table also contains duct class, cross-section area for various round duct sizes and the equivalent diameter of round duct for rectangular ducts. The large numbers in the table are the duct class.

The duct construction class varies from 1 to 6 and depends on the maximum duct side and the semi-perimeter of the ductwork. This is illustrated as follows:

DUCT GLASS	MAX.SIDE (in.)	SEMI-PERIMETER (in.)
1	6 – 17 ½	10 – 23
2	12 – 24	24 – 46
3	26 – 40	32 – 46
4	24 – 88	48 – 94
5	48 – 90	96 – 176
6	90 – 144	96 – 238

Duct class is a numerical representation of relative first costs of the duct work. The larger the duct class, the more expensive the duct. If the duct class is increased but the duct area and capacity remain the same, the following items may be increased:

1. Semi-perimeter and duct surface
2. Weight of material
3. Amount of insulation required

Therefore, for best economics the duct system should be designed for the lowest duct class at the smallest aspect ratio possible. Example 1 illustrates the effect on first cost of varying the aspect ratio for a specified air quantity and static pressure requirement.

Example 1 – Effect of Aspect Ratio on First Cost of the Ductwork

Given:

Duct cross-section area – 5.86 sq. ft.
Space available – unlimited
Low velocity duct system

Find:

The duct dimensions, class, surface area, weight and gage of metal required.

Solution:

1. Enter Table 6 at 5.86 sq. ft and determine the rectangular duct dimensions and duct class (see tabulation).
2. Determine recommended metal gages from Tables 14 and 15 (see tabulation).
3. Determine weight of metal from Table 18 (see tabulation).

DIMENSION (in.)	AREA (sq ft)	ASPECT RATIO	DUCT CONSTR. CLASS
94 X 12	5.86	7.8 : 1	6
84 X 13	5.86	6.5 : 1	5
76 X 14	5.86	5.4 : 1	4
42 X 22	5.86	1.9 : 1	4
30 X 30	5.86	1 : 1	4
32.8 (round)	5.86	-	-
DIMENSION (in.)	**GAGE (U.S.)**	**SURFACE AREA (sq ft/ft)**	**WEIGHT (lb/ft)**
94 X 12	18	17.7	38.3
84 X 13	20	16.2	26.8
76 X 14	20	15.0	24.8
42 X 22	22	10.7	15.1
30 X 30	24	10.0	11.6
32.8 (round)	20	8.6	14.3

When the aspect ratio increases from 1:1 to 8:1, the surface area and insulation requirements increase 70% and the weight of metal increases over three and one-half times. This example also points out that it is possible to construct Class 4 duct, for the given area, with three different sheet metal gages. Therefore, for lowest first cost, ductwork should be designed for the lowest class, smallest aspect ratio and for the lightest gage metal recommended.

Chart 4 illustrates the percent increase in installed cost for changing the aspect ratio of rectangular duct. The installed cost of round duct is also included in this chart. The curve is based on installed cost of 100 ft of round and rectangular duct with various aspect ratios of 1:1 is used as the 100% cost

Friction rate

The operating costs of an air distribution system con be adversely influenced when the rectangular duct sizes are not determined from the table of circular equivalents *(Table 6).* This table is used to obtain rectangular duct sizes that have the same friction rate and capacity as the equivalent round duct. For example, assume that the required duct area for a system is 480 sq. in. and the rectangular duct dimensions are determined directly from this area. The following tabulation shows the resulting equivalent duct diameters and friction rate when 4000 cm. of air is handled in the selected ducts:

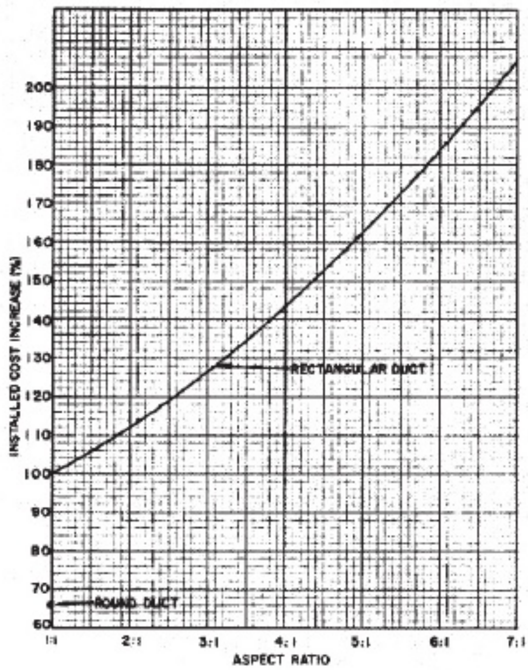


CHART 4 – INSTALLED COST VS ASPECT RATIO

DUCT DIM. (in.)	EQUIV ROUND DUCT DIAM (in.)	FRICTION RATE (in. wg/100ft)	ASPECT RATIO
24 X 20	23.9	.090	1.2 : 1
30 X 16	23.7	.095	1.9 : 1
48 X 10	22.3	.125	4.8 : 1
80 X 6	20.1	.210	13.3 : 1

If a total static pressure requirement of 1 in., based on 100 ft of duct and other equipment is assumed for the above system, the operating cost increases as the aspect ratio increases. This is shown in *Chart 5.*

Therefore, the lowest owning and operating cost occurs where round or Spira-Pipe is used. If round ductwork con not be used because of space limitations, ductwork as square as possible should bb used. An aspect ratio of 1:1 is preferred.

Type of Fittings

In general, fittings can be divided into Class A and Class B as shown in *Table 3*. For the lowest first cost it is desirable to use those fittings shown as Class A since fabrication time for a Class B fitting is approximately 2.5 times that of a Class A fitting.

CHART 5 – OPERATING COST VS ASPECT RATIO

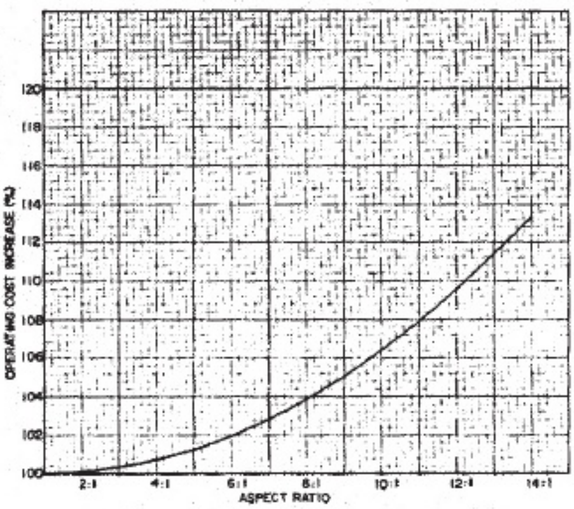
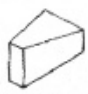


TABLE 3 – DUCT FITTING CLASSES

CLASS A—NO VANED FITTINGS	
Any fitting with constant cross-section dimensions.	
Any fitting with changing radius and constant width.	
Fittings with straight sides and seams.	
CLASS B—ALL VANED FITTINGS	
Any fitting with concentric radii, and changing width.	
Any fitting with eccentric radii and changing width.	

DUCT LAYOUT CONSIDERATIONS

There are several items in duct layout that should be considered before sizing the ductwork, These include duct transformations, elbows, fittings, take-offs, duct condensation and duct condensation and air control.

Transformations

Duct transformations are used to change the shape of a duct of to increase of decrease the duct area. When the shape of a rectangular duct is changed but the cross-sectional area remains the same, a slope of 1 in. in 4 in. should not be exceeded.

Often ducts must be reduced in size to avoid obstructions. It is good practice not to reduce the duct more than 20% of the original area. The recommended slope of the transformation is 1 in. in 7 in. when reducing the duct area. Where it is impossible to maintain this slope, it may be increased to a maximum of 1 in. in 4 in.

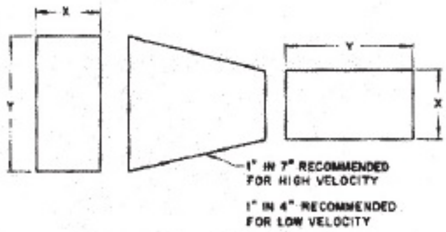
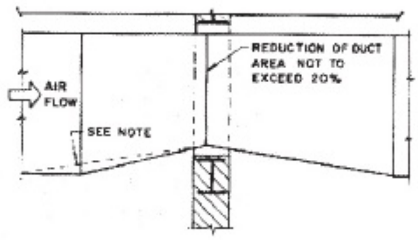


Fig. 19 – Duct Transformation



NOTE: 1:7 slope is recommended for high velocity, 1:4 slope for low velocity.

Fig. 20 – Rectangular Duct Transformation To Avoid Obstruction